THE EFFECT OF A BLOCKING HIGH ON TWO CONSECUTIVE LOWS OVER THE CENTRAL UNITED STATES, JUNE 7–11, 1955

EARL F. ROBINSON AND ELLIS J. JOSEPH

National Weather Analysis Center, U. S. Weather Bureau, Suitland, Md.

1. INTRODUCTION

During the first week of June 1955, ridge conditions dominated the eastern half of the United States. In the upper levels, this ridge moved into position from the west on June 1, a step in the westward progression of a blocking condition that moved onto the continent from the northwestern Atlantic Ocean. (See the preceding article by Hawkins.)

Surface cyclones associated with the deep upper trough immediately west of the ridge were diverted generally northward as they approached the Great Plains region. This is well illustrated by the cyclone tracks, Chart X.

At 500 mb., on June 6, a Low formed in eastern North Dakota in the trough that extended from Fort Smith, Northwest Territories through Huron, S. Dak. to central Texas. This Low moved southeastward along a slightly cyclonically curved path through the east coast ridge (fig. 1), and on June 11 became part of the major trough off the Atlantic Coast. On June 7 (fig. 2), the 500-mb. Low in western Canada showed signs of following in the path of the first Low and on June 8, entered the United States at approximately the 100th meridian. For the next 24 hours the path of the second Low almost coincided with that of the preceding one (fig. 1). At 1500 GMT, June 8, it was forecast by National Weather Analysis Center to be over St. Louis, Mo. in 36 hours, being expected to continue in the path of the first Low but at a somewhat slower rate. Instead, however, after 0300 GMT, June 9 (fig. 3), this Low turned abruptly southward and for 36 hours moved almost due south to a position southwest of Kansas City. Then the High over Hudson Bay weakened, as the blocking condition progressed westward, and the Low began to move eastward. In establishing the relationship between the two Lows and the westward movement of the blocking condition and its components, we shall attempt to account for the unexpected divergence of the path of the second Low from the one preceding it.

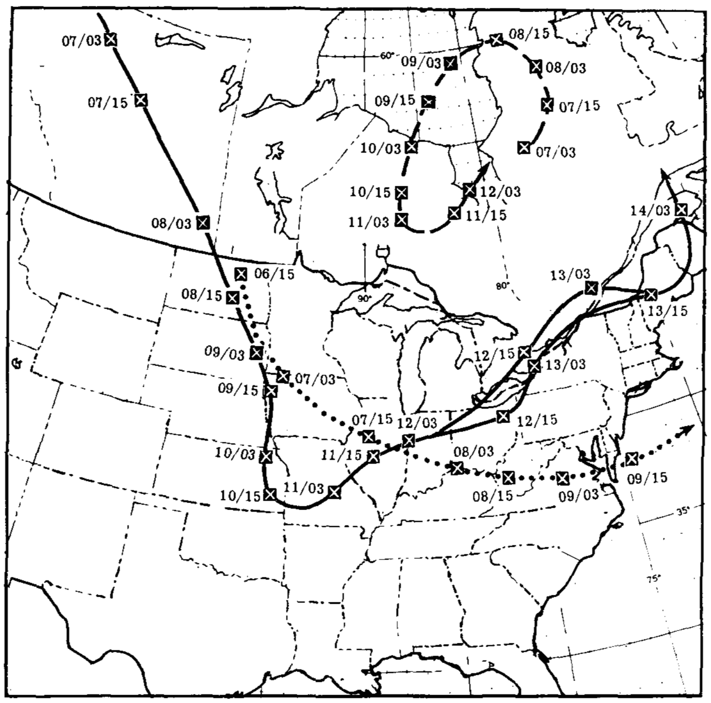

FIGURE 1.—Tracks of 500-mb. centers. Dotted line represents path of first Low; solid line, path of second Low; and dashed line is the path of blocking High. Crosses indicate 12-hour positions of centers.

2. DEPARTURE OF 1000–500-MB. THICKNESS FROM NORMAL

The 500-mb. height departure from normal and the 1000–500-mb. thickness departure from normal charts were investigated with respect to the circulation systems of June 7–11. The two series of charts showed essentially the same pattern, but the thickness departure from normal charts were selected for presentation here because they have the added advantage of presenting the temperatures throughout the area under study.

A comparison of the 1000–500-mb. thickness departure from normal charts of 0300 GMT for June 7 and 9, (figs. 4 and 5) demonstrates well the effect of temperatures in this layer on the movement of the two 500-mb. Lows as they entered the Midwest. At 0300 GMT, June 7 (fig. 4) there was a ridge of positive departures that extended north-south from just east of Hudson Bay to the southeastern States. The area of negative departures from normal centered over Omaha, Nebr. accompanied the cold air associated with the first Low. As this first Low approached the ridge over the Appalachians there was no flow component directed against the cold air that would restrict its eastward movement.

Another action that cannot be ignored in considering the motion of the two Lows is the vortex-pair interaction. Two cyclones in close proximity to one another tend to rotate around each other in a counterclockwise direction. If the pressure field is otherwise flat the vortex-pair effect may be used in an almost objective fashion to determine the instantaneous direction of movement of the centers. As a flat pressure field is rarely the case in the middle latitudes, the relationship may be used only in a highly subjective but nevertheless useful manner. The vortex-pair motion of the two Lows considered here was such as to direct the first Low northeastward.

However, since a northeastward movement would have carried the Low into the opposing northeast flow from around the High, the resultant of these two actions was a movement slightly south of east. No sharp movement to the south could be expected since neither the packing of the 1000–500-mb. thickness departures from normal nor of the 500-mb. contours to the west of the Low indicated a flow component from the north strong enough to be generally associated with any appreciable southward movement. This first Low did move in essentially the direction forecast.

Forty-eight hours later when the second Low entered the Midwest the conditions were strikingly different (figs. 3 and 5). Whereas the first Low had encountered little or no opposing easterly flow components, the second Low met an easterly flow resulting from the progression of the first Low under the High. This flow imposed a much more southerly movement on the second Low. The 500-mb. winds reported at Pittsburgh, Pa., provide a good example of the contrast in flow regimes confronting the two Lows. At 0300 GMT, June 7, Pittsburgh reported a 500-mb. wind of 22 knots from 190°. The winds backed steadily and at 0300 GMT, June 9 were 29 knots from 50°. This was a change from a westerly component of 4 knots acting on the first Low to an easterly component of 22 knots opposing the second Low. Moreover, at 0300 GMT, June 9, the two Lows were significantly closer together and the tendency for vortex-pair interaction was appreciably stronger. This action tended to move the second Low in a path slightly west of south. Also, no negative departures from normal thickness followed the second Low that would tend to move it northeastward in the manner of the first one. The building of the upper level High over the Great Basin and the colder air at 500 mb. in the center of the second Low produced a departure from normal gradient to the west of the second Low almost double what it was when the first Low entered the Midwest. This greatly increased departure from normal gradient plus the more northerly flow to the west of the second Low forced the cold air associated with the Low to move almost due south. Thus, where the first Low was in a field that tended to give it an easterly path, the second Low was surrounded by conditions that individually, and certainly collectively, made mandatory a southward movement.

As the two 500-mb. Lows and the cool air associated with them entered and passed through the Midwest, the weekly average temperatures dropped from the above

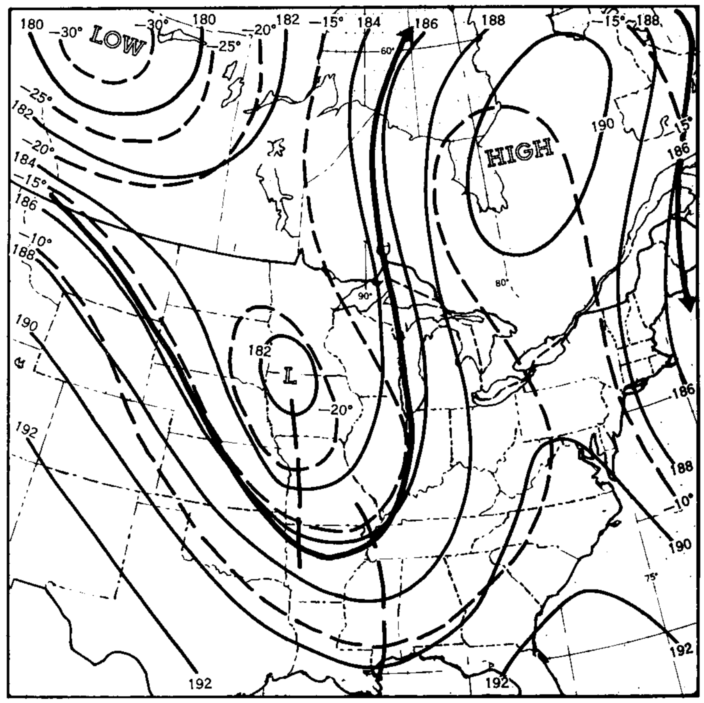

FIGURE 2.—500-mb. chart for 0300 GMT, June 7, 1955. Contours (solid lines) are in hundreds of geopotential feet, isotherms (dashed lines) in degrees Celsius. Heavy line is 300-mb. jet for same time.

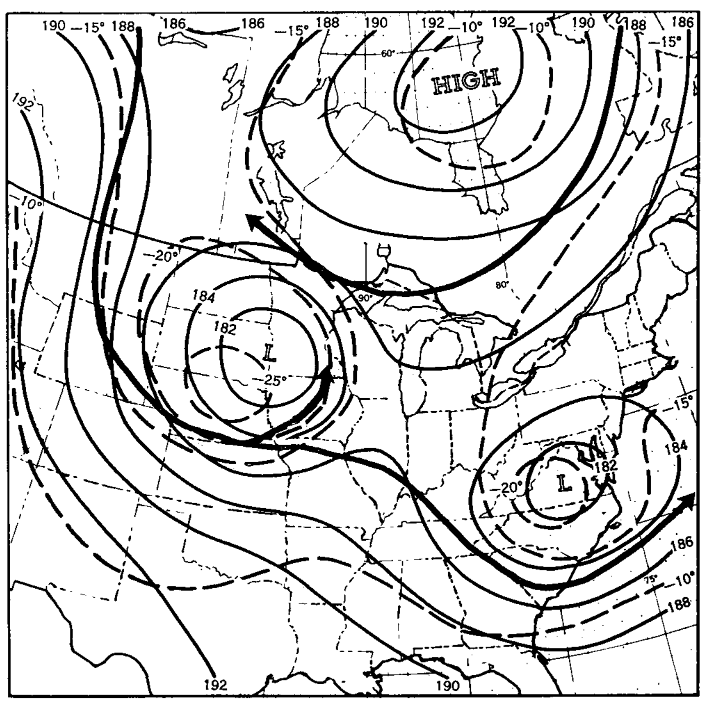

FIGURE 3.—500-mb. chart for 0300 GMT, June 9, 1955.

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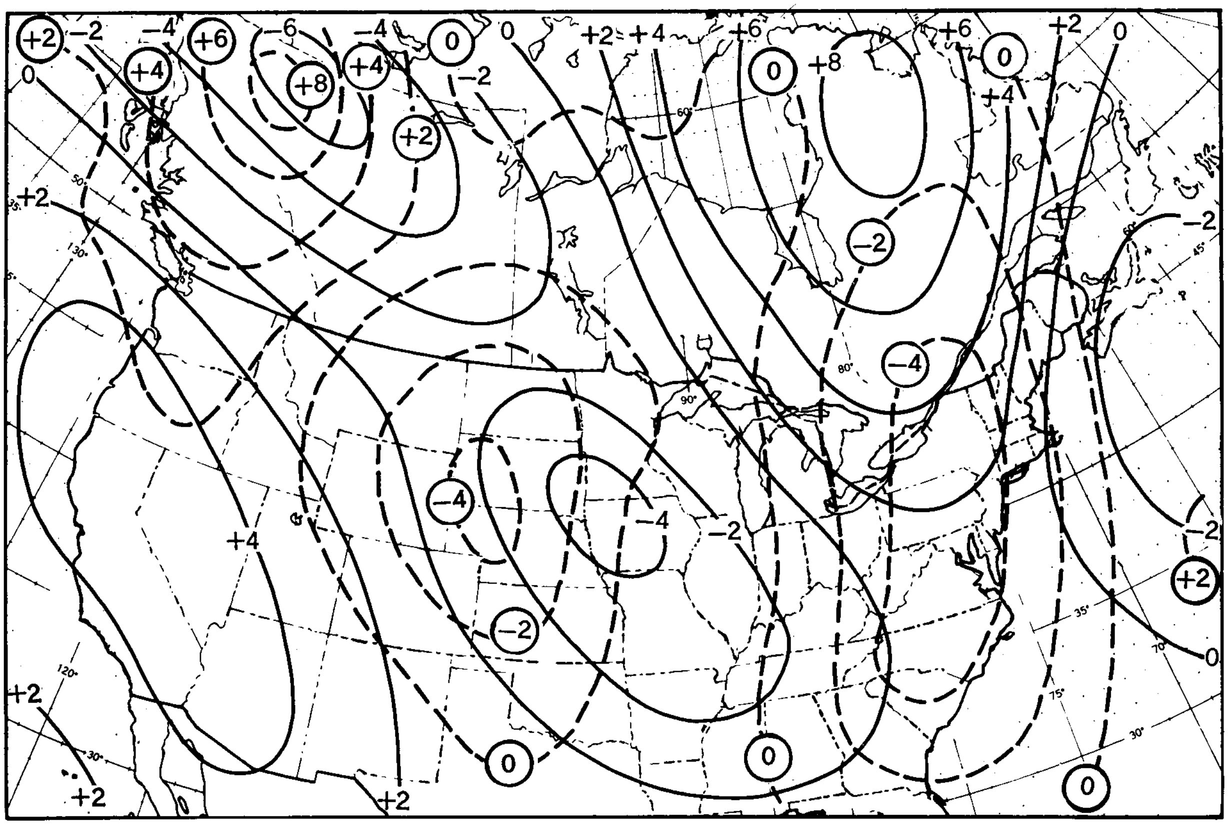

FIGURE 4.—1000–500-mb. thickness departure from normal chart for 0300 GMT, June 7, 1955. Solid lines are departures in hundreds of feet. Dashed lines show changes in hundreds of feet for the 48-hour period *following* this map.

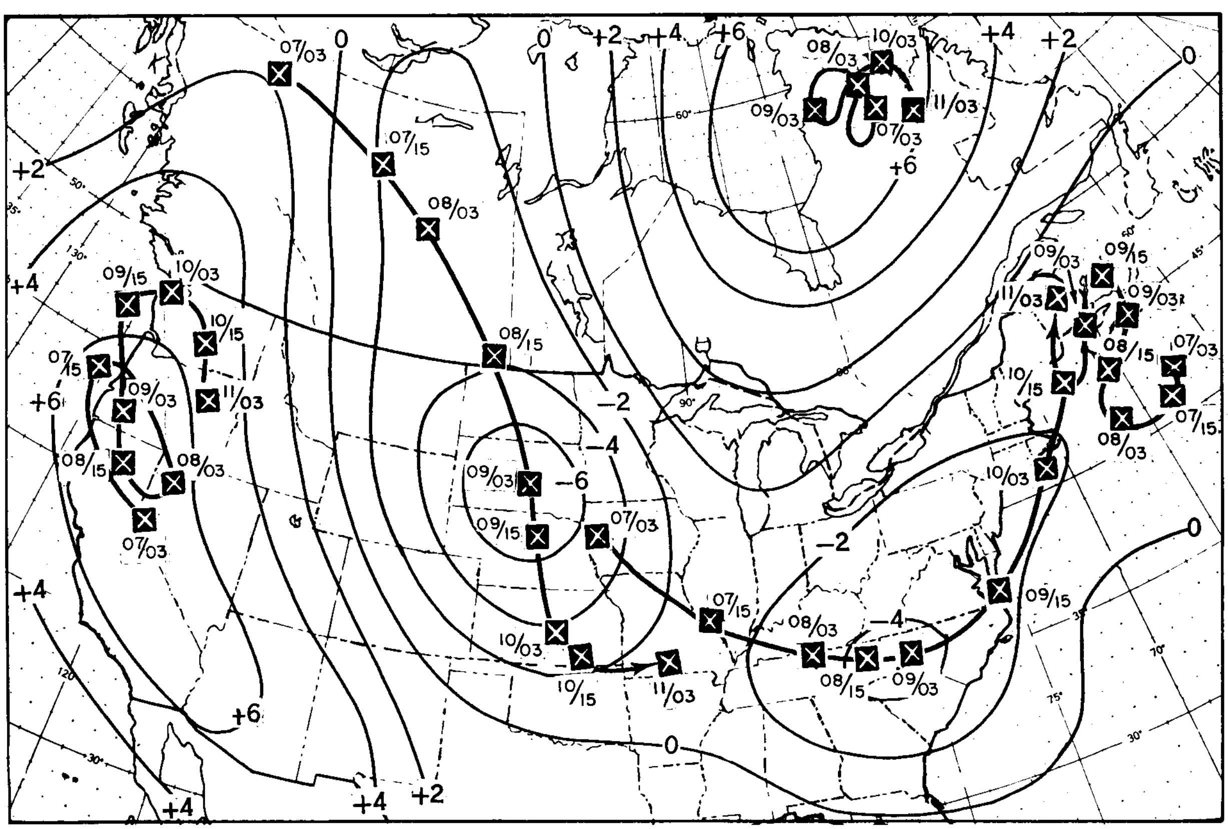

FIGURE 5.—1000–500-mb. thickness departure from normal chart for 0300 GMT, June 9, 1955. Crosses on tracks of anomaly centers denote 12-hour positions.

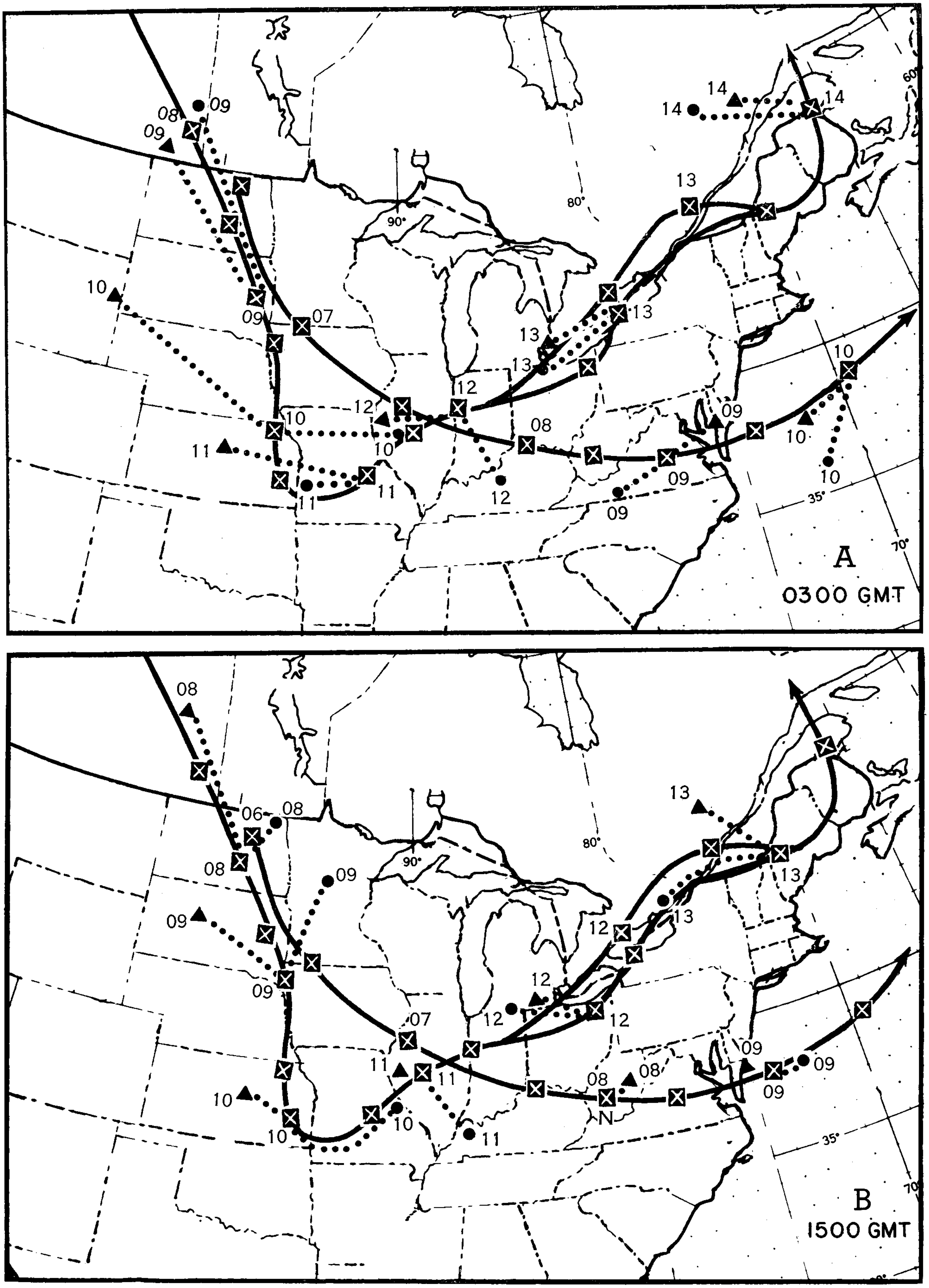

FIGURE 6.—Tracks (solid lines) of centers of two consecutive 500-mb. Lows labeled with day of month. Connected by dotted lines to the observed positions at verifying time are: in (A) the JNWP 36-hour 400-mb. prognosticated positions (triangles) and the NWAC 36-hour 500-mb. prognosticated positions (large dots); in (B) the JNWP 24-hour 400-mb. prognosticated positions and the NWAC 36-hour 500-mb. prognosticated positions.

normal values of the preceding week to as much as 12° F. below normal for the week ending June 13. West of the Continental Divide as the High built over the Great Basin, weekly average temperatures rose from below normal to as much as 12° F. above normal. The area east of the Mississippi River Valley received generous amounts of rain with several stations reporting more than two inches above normal for the week.

3. JETS AT 300 MB.

The movements of the two Lows were studied also in relation to the jets at the 300-mb. level. As the first Low moved into the Midwest the 300-mb. jet associated with it curved northward to its east over the Hudson Bay High then southward and under the Low off the east coast. This pattern prevailed until a trough opened between the first Low and a Low south of Sable Island. The picture then became that of one jet in the westerlies passing under the Lows that were south of the High and another jet circling all but the south quadrant of the High over Hudson Bay. By 0300 GMT, June 9 (fig. 3), the winds on the west-southwest octant of the High diminished to less than 50 knots with the leading edge of the jet extending to Lake Winnipeg.

A rule often used in forecasting the paths of upper level Lows is that their movement will parallel the direction of the maximum wind associated with them. As the first Low moved through the ridge, its path followed well the movement indicated by the single jet maximum associated with it. When the second Low moved into the Midwest (fig. 3), the wind field accompanying it was significantly different. The area of maximum winds in its southern quadrant would, by itself, indicate an eastward movement. But the combined effects of this jet and of the one that passed around the Hudson Bay High and through International Falls, Minn., resulted in a tendency for the Low to stagnate.

The 500-mb. charts, with the 300-mb. jets superimposed on them (figs. 2 and 3), display well the east-west components prevailing as the Lows approached the ridge. The 300-mb. jet south of the Hudson Bay High at 0300 GMT, June 9, was in an area that, relative to the Low centers, was essentially flat 48 hours before. This is another demonstration of the differences in the flows opposing the two Lows on their northeastern quadrants. These easterly components tended to retard the eastward movement of the second Low whereas they were not present at the time of passage of the first Low.

4. THE 500-MB. CHART

The 500-mb. chart for 0300 GMT, June 9 (fig. 3), shows a stronger northerly flow component west of the second Low than was present when the first Low was in approximately the same position (fig. 2). North-south and east-west component flow charts, constructed for this study (not shown) also demonstrate this. In addition the 500-mb. isotherm-contour relationship at 0300 GMT, June 9, indicated cold air advection that would contribute to 500-mb. height falls to the south of the center. The cross-gradient flow indicated on figure 3 was not present at 0300 GMT, June 7, as the first Low entered the Midwest (fig. 2).

The preceding discussion attempts to point out the dominant features that caused the second of the two Lows to move southward. They may be summarized as follows: (1) The northerly component was strengthened to the west of the second Low as the High over the Great Basin built northward with warm air pushing into Canada. (2) Cold air advection into the southern quadrant was indicated for the second Low but not for the first. (3) The easterly flow components were directed against the northeast quadrant of the second Low and were coupled with the appearance of the 300-mb. jet in the south quadrant of the High over Hudson Bay. (4) The vortex-pair motion of the two Lows was active as the second Low moved rapidly into the United States.

5. PROGNOSTIC CHARTS

As this is the first article of this series by National Weather Analysis Center dealing with a synoptic sequence for which the Joint Numerical Weather Prediction (JNWP) unit has issued operational forecasts, some mention of those forecasts may be in order. JNWP makes 12, 24, and 36-hour prognostics from the 1500 GMT charts for the 900-mb., 700-mb. and 400-mb. constant pressure levels, and vertical velocity prognostics for the 800-mb. and 550-mb. levels. The corners of their prognostic area are approximately 45° N., 165° W.; 45° N., 45° W.; 15½° N., 77° W.; and 15½° N., 133° W. As the numerical procedure assumes no vorticity advection and no height change at the boundaries, JNWP charts are trimmed about 5°, 10°, and 15° latitude on the east, north, and west sides respectively before delivery to NWAC to eliminate the areas of maximum "boundary effect."

Under June schedules, the NWAC analysts received the JNWP 24-hour prognostics about 20 to 30 minutes before making the thickness check between the surface and 500-mb. prognostics. After the thickness check the NWAC analysts had from 10 to 30 minutes to consider the JNWP 36-hour prognostics before tracing their prognostics to meet the facsimile deadline at 2006 EST. Due to machine failure on the evening of June 8, both the JNWP 24- and 36-hour prognostics were received after the NWAC facsimile deadline and it is the prognostics made from the 1500 GMT charts on June 8 that show the greatest disagreement between JNWP and NWAC.

Figure 6A shows the tracks of the two 500-mb. Lows under study and the JNWP (400-mb.) and NWAC (500-mb.) 36-hour prognostics verifying on the 0300 GMT charts. Figure 6B includes the two actual storm tracks, the NWAC 36-hour prognostics and the JNWP 24-hour prognostics that verify at 1500 GMT.